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Original Article

Biliary tree variations as viewed by intra-operative cholangiography – Comparing Egyptian versus international data

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ABSTRACT

Aim of the work: The purpose of this study was to evaluate the frequency of anatomical variations and congenital anomalies of intra and extra-hepatic biliary system in our geographical zone in Egypt encountered during open and laparoscopic cholecystectomies through performing routine intraoperative cholangiogram (IOC) during the operation.
Patients and methods: Intraoperative cholangiogram (IOC) was performed for 248 patients undergoing cholecystectomy (open or laparoscopic) at Ain-Shams university specialized hospital (ASUSH), Cairo, Egypt, from May-2011 to April 2015. All IOC's were performed by the hepato-biliary surgeon and reviewed by the radiologist and then compared with the known internationally published anatomical variations. These results were then confirmed by total agreement between: radiologists.
Results: In our study, typical biliary anatomy (type A) was observed in 60% of the cases ($n = 150$ patients) vs 57% published in most references, type B (11.3% $n = 28$ vs 12%), type C1 (11.3% $n = 28$ vs 16%), type C2 (6.5% $n = 16$ vs 4%), type D1 (3.6% $n = 9$ vs 5%), type D2 (2.8% $n = 7$ vs 1%), type E1 (2% $n = 5$ vs 2%), type E2 (0.8% $n = 2$ vs 1%) and type F (1.2% $n = 3$ vs 1%). With regard to the cystic duct variations we found type A, ($n = 190$) the normal direct cystic duct in 76.6% which is nearly similar to the 75% published in most references. However, type B ($n = 30$) was found in 12.1% vs 20% and type C ($n = 28$) in 11.3% vs 5%.
Conclusion: In our small scale study ($n = 248$); the more common typical biliary anatomy is observed here in Egypt at percentages nearly similar to that reported in the international literature. On the other hand, the less common variation types, show prevalence here in Egypt that are different from those reported in the international literature; a finding that could cause a higher number of bile duct injuries in laparoscopic cholecystectomies if not recognized.

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1. Introduction

Detailed awareness of biliary tree divisions with its anatomical variations (which change between different ethnicities and different geographical anthropological zones) is important for safe liver operations. Nevertheless, details in some geographical zones seem scarce as compared to the literature available elsewhere. Thorough

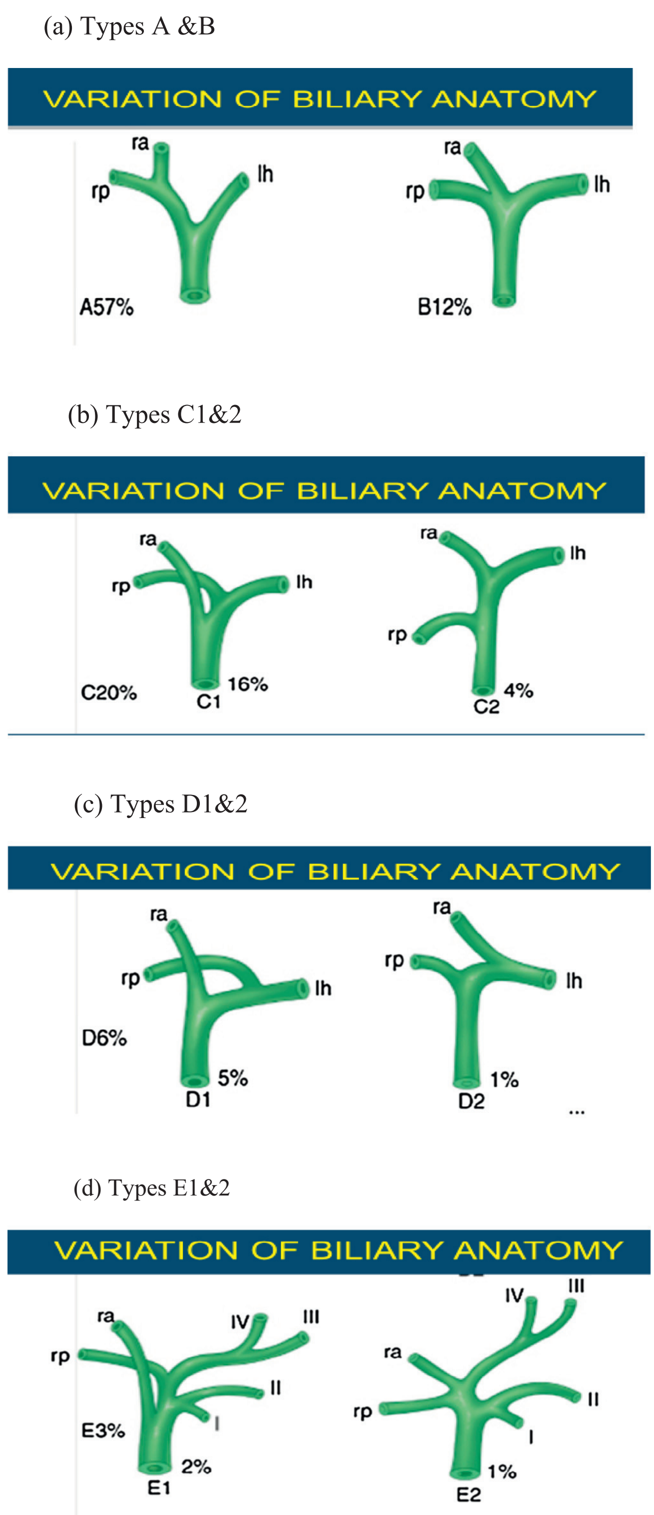


Fig. 1. Variations in biliary anatomy; (a) Types A and B. (b) Types C1 and 2. (c) Types D1 and 2. (1) Types E1 and 2.

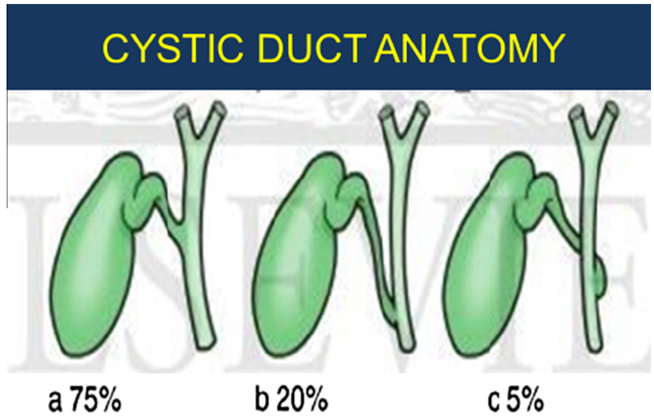


Fig. 2. Cystic duct insertion types.

knowledge of biliary tree divisions and variants is valuable for surgeons to avoid surgical mishaps. Variations in biliary anatomy and cystic duct insertions are illustrated in Figs. 1 and 2 [1].

The right hepatic duct which drains the right hepatic lobe segments (5–6–7–8) is formed by the right posterior duct draining segments 6 and 7, and the right anterior duct, draining segments 5 and 8. The right posterior and right anterior ducts join to give the right hepatic duct. The left hepatic duct drains segments (2–3–4). Right and left hepatic ducts join to form the common hepatic duct. The duct from caudate lobe joins left or right hepatic ducts. This typical anatomy is seen in 58–68% of patients [2].

Familiarity of these variants is important prior to laparoscopic cholecystectomy (LC), however, preoperative diagnosis by routine investigations by sonar and computed tomography is difficult, and they often turn out to be unexpected findings during surgery [3].

However, a wide spectrum of biliary tree malformations along with pancreatic anomalies can nowadays be recognized by radiologic evaluation [4].

Recent advances in MRI, MRCP and Multi-Detector (MD) CT scan have improved image quality greatly and have contributed to increased recognition of these entities [5].

The purpose of this study was to evaluate the frequency of anatomical variations and congenital anomalies of intra and extra- hepatic biliary system in our geographical zone in Egypt encountered during open and laparoscopic cholecystectomies through performing routine IOC during the operation.

2. Patients and methods

Our study was approved by the ethical committee in Ain-Shams university specialized hospital and all the patients participating in this study were well informed about the technique of the operation, the possible benefits and complications, and were encouraged to participate without any pressure, with obtained informed consent containing all the required data.

In our cross-sectional study, intraoperative cholangiogram (IOC) was performed for 248 patients undergoing cholecystectomy (open or laparoscopic) at Ain-Shams university specialized hospital (ASUSH), Cairo, Egypt, from May-2011 to April 2015. All IOC's were performed by the hepato-biliary surgeon and reviewed by the radiologist and then compared with the known internationally published anatomical variations. These results were then confirmed by total agreement between both radiologists.

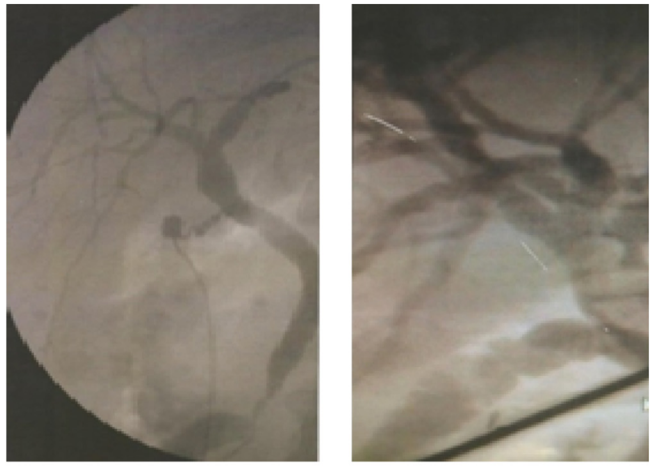
Abdominal ultrasound ($n = 248$) was performed for initial diagnosis. MRCP ($n = 73$) was done for cases of direct hyper bilirubinemia and ERCP ($n = 56$) was done for cases whose MRCP showed a stone in the common bile duct. IOC ($n = 248$) was performed for all cases to evaluate common bile duct caliber and patency throughout its entire course, to negate any residual sludge or stones inside it and to exclude common bile duct strictures or injuries.

2.1. Technique used in IOC during LC

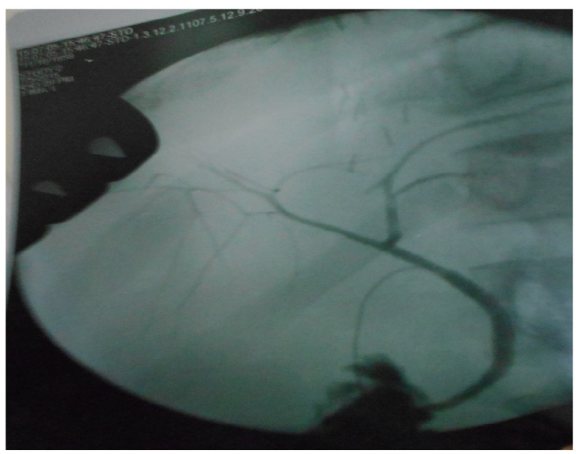
Full dissection of the cystic duct is done followed by the application of a metallic clip at the gall bladder end of the duct; then, a side hole is made in the cystic duct by a scissor proximal to the clip and dilated by the scissor or the hook in longer ducts, followed by introduction of a 6–8 Fr Nelaton catheter via a separate new opening in the right hypochondrium tailored to be in line with the stretched cystic duct into the hole and then tightening of the hole site is done by an atraumatic grasper to prevent backflow of the dye. Advancement of the C-Arm (Phillips BV Pulsera mobile C-arm) was done to the table and then after proper positioning an iodinated contrast agent Urograffin 30% 15 ml was injected through the catheter; then, Antero-posterior and oblique views were taken.

The same technique is applied in open surgery where a 2/0 vicryl suture is used to keep the catheter in place and prevent dye backflow.

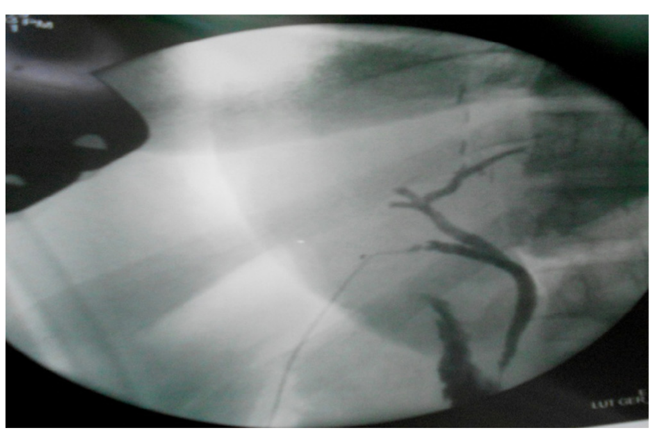
All the cases started as Laparoscopic cholecystectomy except 12 cases who started as open cholecystectomy due to either previous major surgeries involving the gall bladder area, contra-indication of laparoscopy and one case due to a technical problem in the instrument that was discovered just before insufflation. Also we had 16 cases that were converted from laparoscopic approach to open approach due to technical and anatomical difficulties, and intra-operative bleeding in 2 cases of them.



(a) biliary tree variation types A & B in IOC

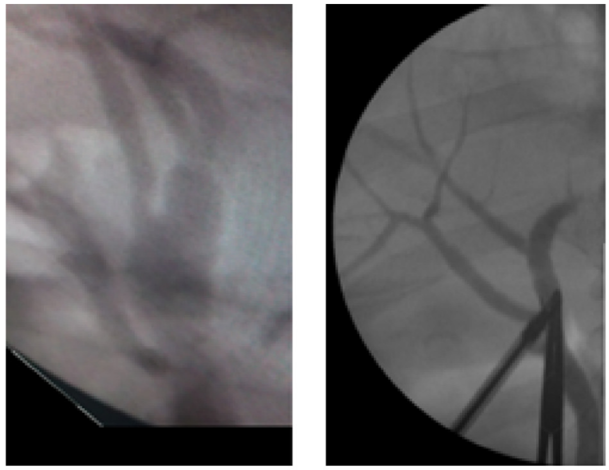


(b) biliary tree variation type A in IOC

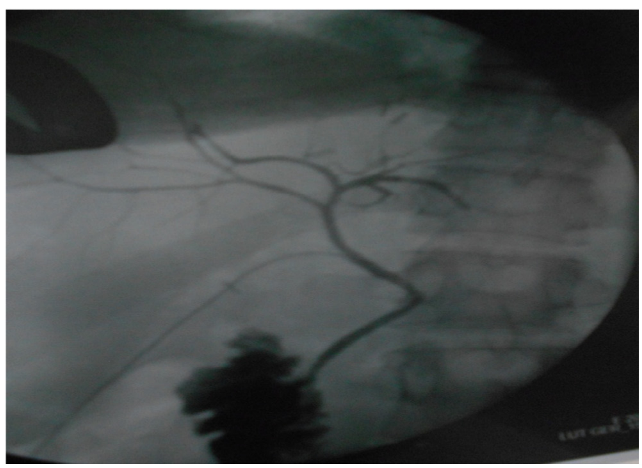


(c) biliary tree variation type B in IOC

Fig. 3. Biliary tree variation types A and B in IOC; (a) biliary tree variation types A and B in IOC. (b) Biliary tree variation type A in IOC. (c) Biliary tree variation type B in IOC.



(a) biliary tree variation types C1 & C2 in IOC.



(b) biliary tree variation type C2 in IOC

Fig. 4. Biliary tree variation type C in IOC; (a) biliary tree variation types C1 and C2 in IOC. (b) Biliary tree variation type C2 in IOC.

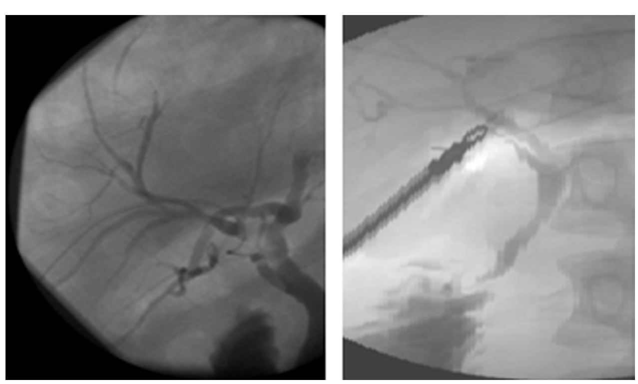


Fig. 5. Biliary tree variation types D1 and D2 in IOC.

The data were evaluated by statistical program SSPS. Mean ± standard deviation was presented for numerical parameters and categorical variables were expressed as n (%) on 95% confidence interval.

3. Results

Total number of patients was 248, (182 females and 66 males).

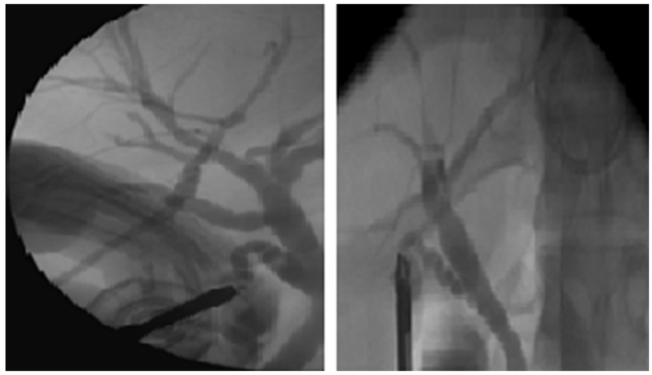


Fig. 6. Biliary tree variation types E1 and E2 in IOC.

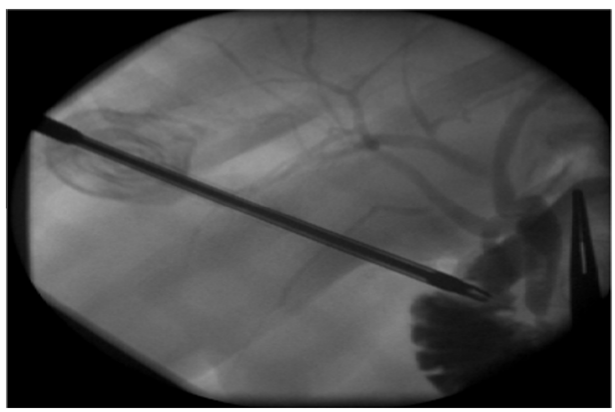


Fig. 7. Biliary tree variation type F in IOC.

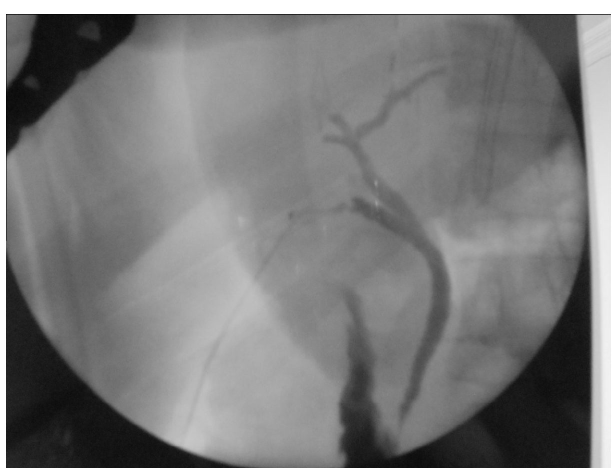


Fig. 8. Type A of cystic duct insertion in IOC.

The anatomical variations observed in our work here in Egypt vs. the internationally published biliary tree anatomic variations were as follows.

Typical biliary anatomy (type A) was observed in 60% of the cases (n = 150 patients) *vs* 57% published in most references, type B (11.3% n = 28*vs* 12%), type C_1 (11.3% n = 28*vs* 16%), type C_2 (6.5% n = 16 *vs* 4%), type D_1 (3.6% n = 9 *vs* 5%), type D_2 (2.8% n = 7 *vs* 1%), type E_1 (2% n = 5 *vs* 2%), type E_2 (0.8% n = 2 *vs* 1%) and type F (1.2% n = 3 *vs* 1%).

With regard to the cystic duct variations we found type A, (n = 190) the normal direct cystic duct in 76.6% which is nearly similar to the 75% published in most references.

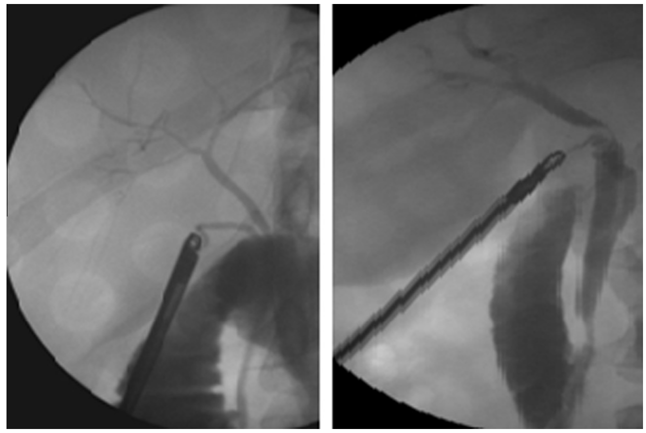


Fig. 9. Types B and C of cystic duct insertions in IOC.

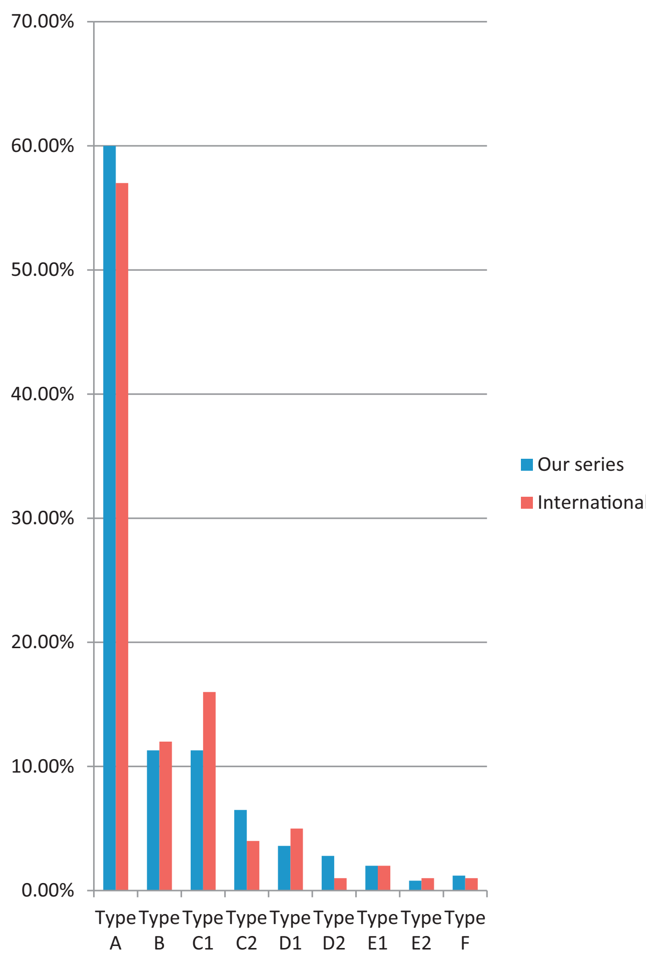


Fig. 10. Chart showing biliary tree anatomic variations compared to international results.

However, type B ($n = 30$) was found in 12.1% vs 20% and type C ($n = 28$) in 11.3% vs 5% (Figs. 3–9).

Biliary tree variations in our Egyptian study compared to international percentages respectively are shown in Fig. 10.

Cystic duct variations in our Egyptian study compared to international percentages respectively are shown in Fig. 11.

Patients' demographics and data are illustrated in Tables 1–4.

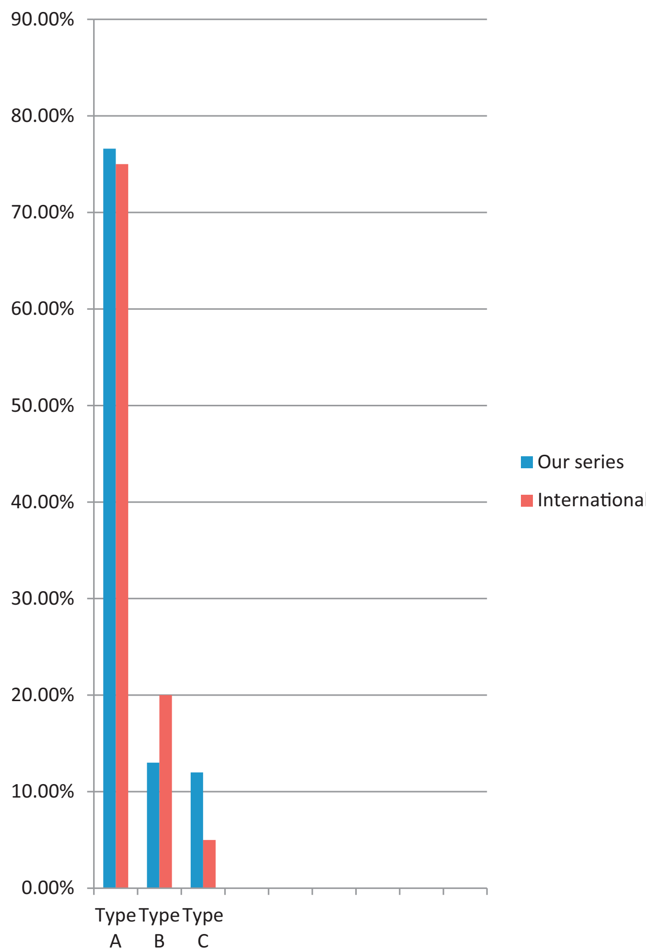


Fig. 11. Chart showing cystic duct anatomic variations compared to international results.

Table 1
Pre-operative patients' characteristics.

Characteristics	No. of pts.	%
Sex		
Female	182	73.3
Male	66	26.7
Age (years)		
Mean age	47 ± 8.41	
Presentation		
Pain in right hypochondrium + fatty dyspepsia	158	63.2
Jaundice	62	24.8
Acute cholecystitis	110	44
Biliary pancreatitis	48	19.2

4. Discussion

Thorough evaluation of biliary tree is mandatory for hazard-free liver surgery that accomplishes its goals. Bile duct injuries usually develop due to a number of predisposing factors encountered during cholecystectomy, including: acute cholecystitis, anatomical bile duct variations, intraoperative bleeding from the cystic or hepatic arteries, and finally, failure to identify the structures of the triangle of Calot. These factors usually result in injuries that are secondary to surgeon's misperception rather than shortcomings in surgical skill, knowledge, or judgment [6].

In one published series, sixty-three patients were referred with bile duct injury alone (45 patients) or vasculobiliary injury (18). Thirty patients (48 percent) had septic complications before transfer. Twenty-six patients (41 percent) had long-term biliary complications over a median follow-up of 96 (range 12–245) months. Nine patients (3 with bile duct injury, 6 with vasculobiliary injury) required further interventions after a median of 22 (8–38) months; five required biliary surgical revision and four percutaneous dilatation of biliary strictures. Vasculobiliary injury and injury-related sepsis were independent risk factors for treatment failure [6].

Although there were many studies at several nations, bile duct variations are rarely investigated here in Egypt, with lack of valid local information and classification rather than what's present in textbooks.

Biliary tree variation ratio between females and males is 31 and sometimes up to 41, as reported in some European studies [7]. This fact seems to be explainable embryologically.

Table 2
Pre-operative investigations.

Investigations	No. of pts.	Elevated in %
Laboratory work		
Liver function tests(LFT)		
Alkaline phosphatase	85	34%
Total bilirubin	118	47.2%
Direct bilirubin	73	29.2%
AST	168	67.2%
ALT	127	50.8%
Pancreatic workup		
S. amylase	78	31.2%
S. lipase	64	25.6%
Radiological		
Abdominal U/S		
Gall stone(s)	218	87.2%
Thick **GB** wall	232	92.8%
Pericholecystic fluid	93	37.2%
Dilated CBD	49	19.6%
Stone in CBD	41	16.4%
MRCP		
Dilated CBD	59	23.6%
Stone in CBD	56	22.4%
ERCP		
Stone in CBD	56	
Stone extraction	49	

Table 3
Operative findings.

Intra-operative findings	No. of patients	%
Intra-Operative Cholangiogram (IOC)		
Bile duct variations		
Type A	150	60
Type B	28	11.3
Type C		
C1	28	11.3
C2	16	6.5
Type D		
D1	9	3.6
D2	7	2.8
Type E		
E1	5	2
E2	2	0.8
Type F	3	1.2
Union of cystic duct and CHD		
a - angular union	190	76.6
b - parallel union	30	12.1
c - spiral union	28	11.3

In another published study series, type 1 (typical) biliary tree was seen in 64.5% of patients. Type 2 (trifurcation) was noted in 14.0% of patients. Type 3a (left main hepatic duct receiving right posterior duct) was seen in 12.0% of patients and type 3b (common hepatic duct receiving right posterior duct) was noted in 8.0%. Females commonly showed biliary tree variants more than males ($P = 0.005$). Type 2 biliary tree female to male ratio was 3.7–1. Type 3b biliary tree female to male ratio was 1.7–1. Anatomic variants seem to be more frequent in females, probably as a consequence of different embryologic developments.

Table 4
Post-operative patients' characteristics.

Parameters	No. of pts.	%
Post-operative comp.		
Bleeding	5	2
Bile leakage	3	1.2
Port site sepsis	14	5.6
Laparotomy	2	0.8
Others	11	4.4
Hospital stay		
1 day	162	64.8
2 days	51	20.4
3 days	18	7.2
4 days	7	2.8
5 days	2	0.8
6 days	6	2.4
⩾7 days	4	1.6

Standard biliary tree was noted in 64.5%, but females commonly showed variation; where standard tree prevalence was 55.0% in females and 74.0% in males. Geographically, abundance of standard tree was 60% in Europeans and Americans and 65% in Asians [8].

In our study we have had 182 females and 66 males. No specific difference regarding biliary anomalies was noted between both sexes. This may be attributed to the smaller number of males included.

The published data reveal that Americans and Europeans have nearly same percentages of standard biliary tree structure because ethnically they are both Caucasians [9].

This is opposed to Asians who show more common standard anatomy, although Sharma reports argue against this obvious discrepancy [10].

5. Conclusion

Thorough awareness of biliary tree details saves surgeons and patients a lot of injuries that may be of drastic sequelae causing major morbidities during hepato-biliary procedures. In our small scale study ($n = 248$); the more common typical biliary anatomy is observed here in Egypt at percentages nearly similar to that reported in the international literature. On the other hand, the less common variation types, show prevalences here in Egypt that are different from those reported in the international literature; a finding that could cause a higher number of bile duct injuries in laparoscopic cholecystectomies if not recognized.

Conflict of interest

The authors declare that there are no conflicts of interests.

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